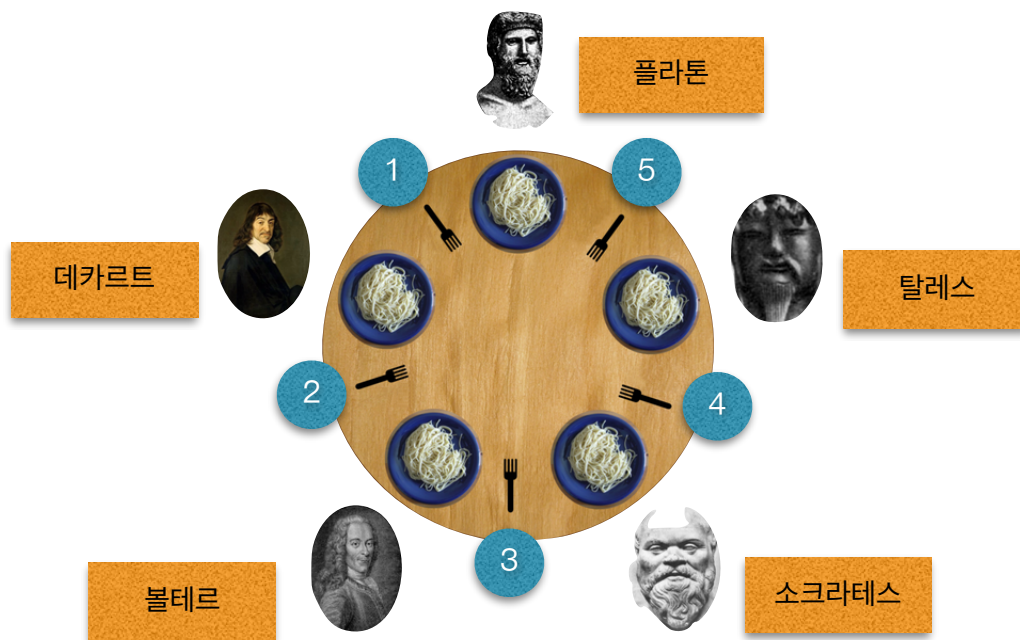# #4. Dining Philosopher

1. **Dining Philosopher 문제를 세마포를 이용하여 구현하시오.**
   - 젓가락 한짝은 세마포 주머니의 구슬 한개로 표현
   - Deadlock에 대한 대비가 없이 작성
   - printf() 를 적절히 사용하여 중간 상태를 출력

2. **Deadlock을 다음 두가지 방법으로 Prevention(예방)하시오.**
   - Circular wait 조건을 깨는 방법
   - 젓가락을 한꺼번에 가져와서 Hold & Wait 조건을 깨는 방법

3. **Deadlock이 걸리는 상태와 이 문제가 해결된 두가지 종류의 상태를 보여주는 실행 결과를 제시하고 설명하시오.**

 원탁 위에 스파게티 다섯 그릇과 다섯 개의 포크가 놓여져 있다. 다섯명의 철학자는 스파게티가 먹고 싶다. 하지만 존엄하디 존엄한 그들은 반드시 양 손에 포크를 집어야만 스파게티를 먹을 수 있다. 물론 그들은 다른 사람의 포크를 빼앗거나 하는 야만적인 행위를 하지 않는 고고한 철학자들이다. 따라서 그들이 생각한 스파게티를 먹는 과정은 다음과 같다.

1. **왼쪽 포크를 집을 수 있을 때 까지, 가만히 생각하고 있다가, 집을 수 있을 때 냉큼 왼쪽 포크를 집는다**
2. **오른쪽 포크를 집을 수 있을 때 까지, 가만히 생각하고 있다가, 집을 수 있을 때 냉큼 오른쪽 포크를 집는다**
3. **양 손에 포크를 집었으면, 한동안 스파게티를 먹는다**
4. **스파게티를 먹고 난 뒤, 오른손에 집은 포크를 내려놓는다**
5. **오른손에 집은 포크를 내려놓은 뒤, 왼손에 집은 포크를 내려놓는다**
6. **지금까지의 과정을 처음부터 다시 반복한다**

 이러한 일련의 과정은 몇몇의 철학자가 다른 철학자들 보다 스파게티를 적게 먹거나 아얘 못 먹는 상황이 발생할 수 있다. 심지어 다섯명의 철학자가 동시에 왼손에 포크를 집어버리는 상황엔, 아무도 스파게티는 먹지 않고, 생각만 영원히 하게되는 일이 벌어지게 된다. (Deadlock 에 의한 Resource starvation에 이 발생했다.)

다음에서 철학자들의 식사과정 시뮬레이션을 구현한 후 확인해 보았습니다. 각 철학자들은 다음 코드와 같은 행동을 취합니다.

```c
void *__dining_philosophier_f__(void *data) {

    int pid, i;
    char name[30];
    int leftHand, rightHand;

    struct philosophier_info *param = data;

    pid = param->pid;
    strcpy(name, param->name);
    if (( leftHand = initsem(param->leftHand, 1) ) < 0)
            ErrHandling ("init leftHand Err.");
    if (( rightHand = initsem(param->rightHand, 1) ) < 0)
            ErrHandling ("init rightHand Err.");


    for(i = 1; i <= 100; i++) {

      printf("[Thread ID : %d] \'%s\' wants to pick up the [left fork] ! \n",
                    pid, name);
      p(leftHand);
      printf("[Thread ID : %d] \'%s\' successfully picked up the [left fork] ! \n",
                    pid, name);

      printf("[Thread ID : %d] \'%s\' wants to pick up the [right fork] ! \n",
                    pid, name);
      p(rightHand);
      printf("[Thread ID : %d] \'%s\' successfully picked up the [right fork] ! \n",
                    pid, name);

      usleep(100000);//eating 0.1 sec
      printf("[Thread ID : %d] \'%s\' successfully eat Spaghetti ! \n",
                    pid, name);

      printf("[Thread ID : %d] \'%s\' wants to throw the [right fork] ! \n",
                    pid, name);
      v(rightHand);
      printf("[Thread ID : %d] \'%s\' successfully throw the [right fork] with hand ! \n",
                    pid, name);

      printf("[Thread ID : %d] \'%s\' wants to throw the [left fork] ! \n",
                    pid, name);
      v(leftHand);
      printf("[Thread ID : %d] \'%s\' successfully throw the [left fork] with hand ! \n",
                    pid, name);

      printf("\n[Thread ID : %d] \'%s\' ate spaghetti [%d] times !! \n\n",
                    pid, name, i);
    }

    return 0;
}
```

데카르트, 볼테르, 소크라테스, 탈레스, 그리고 플라토의 이름을 가진 다섯 스래드가 위 함수를 진행하게 됩니다.

프로그램을 실행해보았습니다. 다음은 터미널 출력 전문입니다.

```
Last login: Sun Apr 13 23:52:47 on ttys000
johnnycloud:~ cheh344$ /Users/cheh344/Dropbox/Lecture/Operating\ Systems/OS_HW4/OS_HW4/
HW_4 f

#########################################################################

< Simple Semaphore Testing 1  - Different semaphore Key >

[Thread id : 1, Semaphore key :  10002] Enter critical section.
[Thread id : 1, Semaphore key :  10002] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :  10003] Enter critical section.
[Thread id : 2, Semaphore key :  10003] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :  10004] Enter critical section.
[Thread id : 3, Semaphore key :  10004] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :  10002] After sleep (0.01msec).
[Thread id : 2, Semaphore key :  10003] After sleep (0.01msec).
[Thread id : 1, Semaphore key :  10002] Out critical section.

[Thread id : 3, Semaphore key :  10004] After sleep (0.01msec).
[Thread id : 2, Semaphore key :  10003] Out critical section.

[Thread id : 3, Semaphore key :  10004] Out critical section.

< Simple Semaphore Testing 2  - Same semaphore Key >

[Thread id : 1, Semaphore key :  10002] Enter critical section.
[Thread id : 1, Semaphore key :  10002] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :  10002] After sleep (0.01msec).
[Thread id : 1, Semaphore key :  10002] Out critical section.

[Thread id : 2, Semaphore key :  10002] Enter critical section.
[Thread id : 2, Semaphore key :  10002] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :  10002] After sleep (0.01msec).
[Thread id : 2, Semaphore key :  10002] Out critical section.

[Thread id : 3, Semaphore key :  10002] Enter critical section.
[Thread id : 3, Semaphore key :  10002] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :  10002] After sleep (0.01msec).
[Thread id : 3, Semaphore key :  10002] Out critical section.

#########################################################################

< Dining Philosopher  - There are five Philosopher(s), Deadlock Prevention : [f] >

[Thread ID : 1] 'René Descartes' wants to pick up the [left fork] !
[Thread ID : 1] 'René Descartes' successfully picked up the [left fork] !
[Thread ID : 1] 'René Descartes' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully picked up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [left fork] !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [left fork] !
[Thread ID : 3] 'Σωκράτης' successfully picked up the [left fork] !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [right fork] !
[Thread ID : 3] 'Σωκράτης' successfully picked up the [right fork] !
[Thread ID : 4] 'Θαλής' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully picked up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to pick up the [right fork] !
```

```
[Thread ID : 1] 'René Descartes' successfully eat Spaghetti !
[Thread ID : 3] 'Σωκράτης' successfully eat Spaghetti !
[Thread ID : 1] 'René Descartes' wants to throw the [right fork] !
[Thread ID : 3] 'Σωκράτης' wants to throw the [right fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [right fork] with hand !
[Thread ID : 3] 'Σωκράτης' successfully throw the [right fork] with hand !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [left fork] !
[Thread ID : 1] 'René Descartes' wants to throw the [left fork] !
[Thread ID : 4] 'Θαλής' successfully picked up the [left fork] !
[Thread ID : 3] 'Σωκράτης' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [left fork] with hand !
[Thread ID : 4] 'Θαλής' wants to pick up the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully picked up the [right fork] !
[Thread ID : 3] 'Σωκράτης' successfully throw the [left fork] with hand !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [right fork] !

[Thread ID : 1] 'René Descartes' ate spaghetti [1] times !!


[Thread ID : 3] 'Σωκράτης' ate spaghetti [1] times !!

[Thread ID : 1] 'René Descartes' wants to pick up the [left fork] !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully eat Spaghetti !
[Thread ID : 2] 'François Marie Arouet' successfully eat Spaghetti !
[Thread ID : 5] 'Πλάτων' wants to throw the [right fork] !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [right fork] with hand !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [right fork] with hand !
[Thread ID : 1] 'René Descartes' successfully picked up the [left fork] !
[Thread ID : 3] 'Σωκράτης' successfully picked up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [left fork] !
[Thread ID : 1] 'René Descartes' wants to pick up the [right fork] !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [left fork] with hand !
[Thread ID : 4] 'Θαλής' successfully picked up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [left fork] with hand !
[Thread ID : 1] 'René Descartes' successfully picked up the [right fork] !

[Thread ID : 5] 'Πλάτων' ate spaghetti [1] times !!


[Thread ID : 2] 'François Marie Arouet' ate spaghetti [1] times !!

[Thread ID : 5] 'Πλάτων' wants to pick up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [left fork] !
[Thread ID : 4] 'Θαλής' successfully eat Spaghetti !
[Thread ID : 4] 'Θαλής' wants to throw the [right fork] !
[Thread ID : 4] 'Θαλής' successfully throw the [right fork] with hand !
[Thread ID : 4] 'Θαλής' wants to throw the [left fork] !
[Thread ID : 1] 'René Descartes' successfully eat Spaghetti !
[Thread ID : 4] 'Θαλής' successfully throw the [left fork] with hand !
[Thread ID : 5] 'Πλάτων' successfully picked up the [left fork] !
[Thread ID : 3] 'Σωκράτης' successfully picked up the [right fork] !
[Thread ID : 1] 'René Descartes' wants to throw the [right fork] !

[Thread ID : 4] 'Θαλής' ate spaghetti [1] times !!

[Thread ID : 5] 'Πλάτων' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [right fork] with hand !
[Thread ID : 4] 'Θαλής' wants to pick up the [left fork] !
```

[Thread ID : 2] 'François Marie Arouet' successfully picked up the [left fork] !
[Thread ID : 1] 'René Descartes' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [left fork] with hand !
[Thread ID : 5] 'Πλάτων' successfully picked up the [right fork] !

[Thread ID : 1] 'René Descartes' ate spaghetti [2] times !!

[Thread ID : 1] 'René Descartes' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully eat Spaghetti !
[Thread ID : 3] 'Σωκράτης' successfully eat Spaghetti !
[Thread ID : 5] 'Πλάτων' wants to throw the [right fork] !
[Thread ID : 3] 'Σωκράτης' wants to throw the [right fork] !
[Thread ID : 3] 'Σωκράτης' successfully throw the [right fork] with hand !
[Thread ID : 3] 'Σωκράτης' wants to throw the [left fork] !
[Thread ID : 3] 'Σωκράτης' successfully throw the [left fork] with hand !

[Thread ID : 3] 'Σωκράτης' ate spaghetti [2] times !!

[Thread ID : 5] 'Πλάτων' successfully throw the [right fork] with hand !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [left fork] !
[Thread ID : 1] 'René Descartes' successfully picked up the [left fork] !
[Thread ID : 4] 'Θαλής' successfully picked up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [right fork] !
[Thread ID : 5] 'Πλάτων' wants to throw the [left fork] !
[Thread ID : 1] 'René Descartes' wants to pick up the [right fork] !
[Thread ID : 4] 'Θαλής' wants to pick up the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [left fork] with hand !
[Thread ID : 4] 'Θαλής' successfully picked up the [right fork] !

[Thread ID : 5] 'Πλάτων' ate spaghetti [2] times !!

[Thread ID : 5] 'Πλάτων' wants to pick up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully eat Spaghetti !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [right fork] with hand !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [left fork] with hand !

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [2] times !!

[Thread ID : 2] 'François Marie Arouet' wants to pick up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [right fork] !
[Thread ID : 4] 'Θαλής' successfully eat Spaghetti !
[Thread ID : 4] 'Θαλής' wants to throw the [right fork] !
[Thread ID : 4] 'Θαλής' successfully throw the [right fork] with hand !
[Thread ID : 4] 'Θαλής' wants to throw the [left fork] !
[Thread ID : 4] 'Θαλής' successfully throw the [left fork] with hand !

[Thread ID : 4] 'Θαλής' ate spaghetti [2] times !!

[Thread ID : 5] 'Πλάτων' successfully picked up the [left fork] !
[Thread ID : 4] 'Θαλής' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to pick up the [right fork] !
[Thread ID : 4] 'Θαλής' successfully picked up the [left fork] !
[Thread ID : 4] 'Θαλής' wants to pick up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully eat Spaghetti !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [right fork] with hand !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [left fork] with hand !

```
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [3] times !!

[Thread ID : 2] 'François Marie Arouet' wants to pick up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully eat Spaghetti !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [right fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [right fork] with hand !
[Thread ID : 2] 'François Marie Arouet' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully throw the [left fork] with hand !

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [4] times !!

[Thread ID : 3] 'Σωκράτης' successfully picked up the [left fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [left fork] !
[Thread ID : 1] 'René Descartes' successfully picked up the [right fork] !
[Thread ID : 3] 'Σωκράτης' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully eat Spaghetti !
[Thread ID : 1] 'René Descartes' wants to throw the [right fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [right fork] with hand !
[Thread ID : 1] 'René Descartes' wants to throw the [left fork] !
[Thread ID : 2] 'François Marie Arouet' successfully picked up the [left fork] !
[Thread ID : 1] 'René Descartes' successfully throw the [left fork] with hand !
[Thread ID : 5] 'Πλάτων' successfully picked up the [right fork] !
[Thread ID : 2] 'François Marie Arouet' wants to pick up the [right fork] !

[Thread ID : 1] 'René Descartes' ate spaghetti [3] times !!

[Thread ID : 1] 'René Descartes' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully eat Spaghetti !
[Thread ID : 5] 'Πλάτων' wants to throw the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [right fork] with hand !
[Thread ID : 5] 'Πλάτων' wants to throw the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [left fork] with hand !

[Thread ID : 5] 'Πλάτων' ate spaghetti [3] times !!

[Thread ID : 5] 'Πλάτων' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully picked up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to pick up the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully picked up the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully eat Spaghetti !
[Thread ID : 5] 'Πλάτων' wants to throw the [right fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [right fork] with hand !
[Thread ID : 5] 'Πλάτων' wants to throw the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully throw the [left fork] with hand !

[Thread ID : 5] 'Πλάτων' ate spaghetti [4] times !!

[Thread ID : 5] 'Πλάτων' wants to pick up the [left fork] !
[Thread ID : 5] 'Πλάτων' successfully picked up the [left fork] !
[Thread ID : 5] 'Πλάτων' wants to pick up the [right fork] !
[Thread ID : 1] 'René Descartes' successfully picked up the [left fork] !
[Thread ID : 1] 'René Descartes' wants to pick up the [right fork] !
```
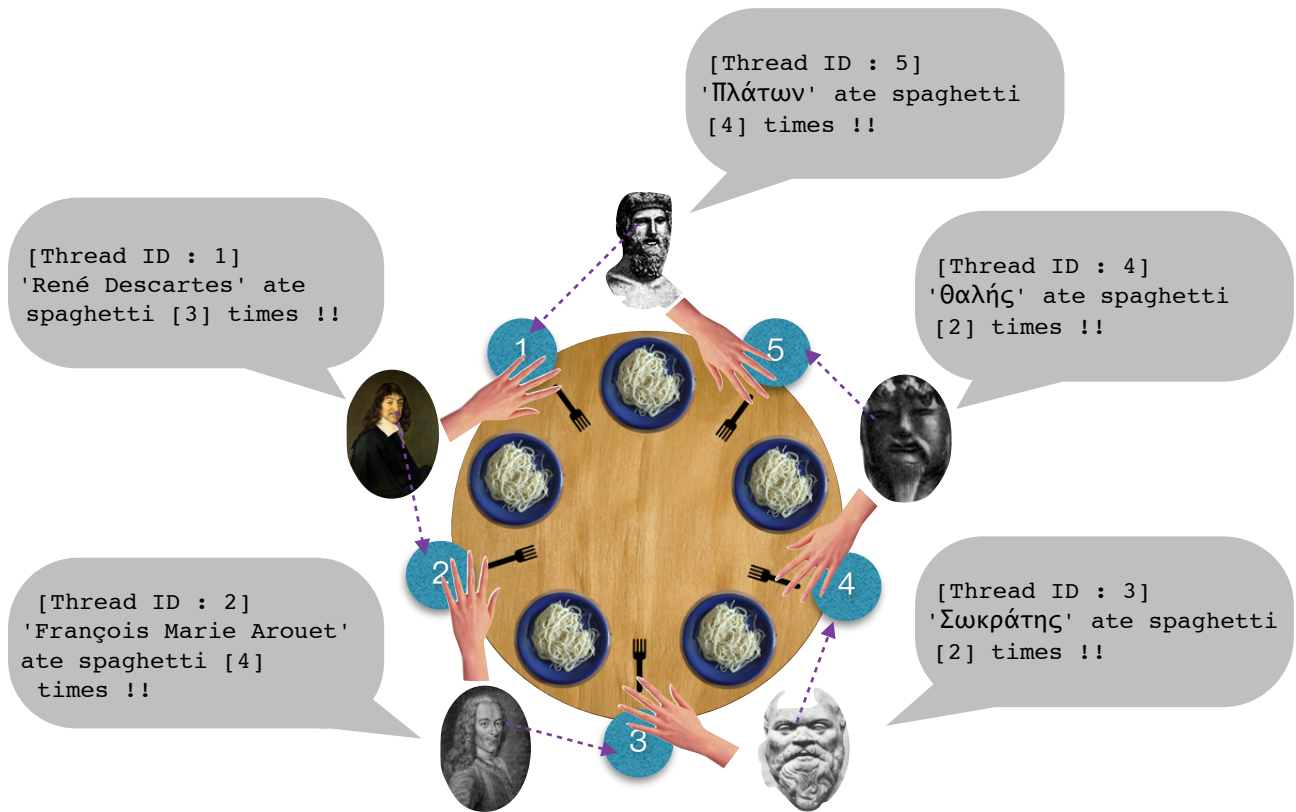
마지막 줄을 마지막으로 더이상의 출력은 없었습니다. 이 상황을 다음 그림과 같이 나타 낼 수 있습니다.

[Thread ID : 5]
'Πλάτων' ate spaghetti
[4] times !!

[Thread ID : 1]
'René Descartes' ate
spaghetti [3] times !!

[Thread ID : 4]
'Θαλής' ate spaghetti
[2] times !!

[Thread ID : 2]
'François Marie Arouet'
ate spaghetti [4]
times !!

[Thread ID : 3]
'Σωκράτης' ate spaghetti
[2] times !!
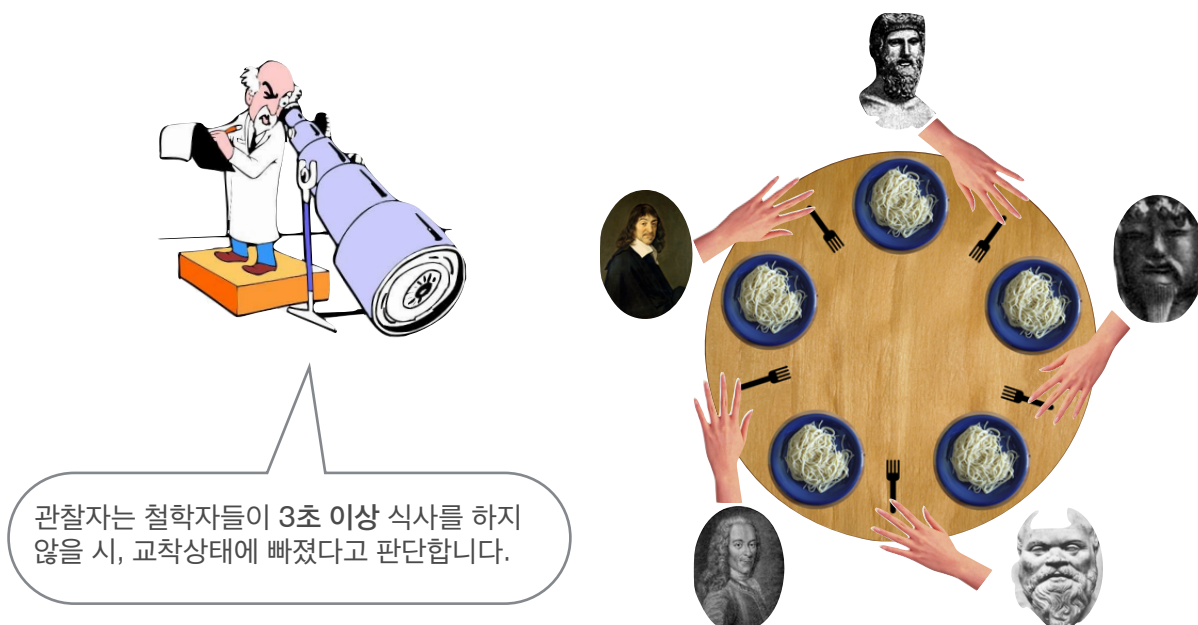
[그들은 결국 스파게티를 먹지 못해 아사하게 될 것 입니다.]

위 그림을 통해 알 수 있는 현 상태의 문제점으로는

　　1.　**철학자들이 공평하게 식사를 하지 못했다.**
　　2.　**모든 철학자들이 왼손에 포크를 잡고는, 옆 철학자가 잡고있는 포크를 놓아주기만 영원히 기다린다.**

위의 두 가지로 들 수 있겠습니다.

먼저, 문제를 타계하고자 관찰자를 두어보기로 하였습니다. 관찰자는 철학자들이 교착상태에 빠졌을 때, 그들의 왼손에 쥐고 있는 포크를 강제로 빼앗아 테이블에 두는 행위를 합니다. (이로써 preempt한 상태를 만들어 cricular-wait 상황을 해결합니다.)

관찰자는 철학자들이 **3초 이상** 식사를 하지 않을 시, 교착상태에 빠졌다고 판단합니다.

포크를 쥔 상태는 더이상 문제가 되지 않기에, 철학자가 얼마나 먹고 있는지만 출력하게 하였습니다.

```
##############################################################################
< Simple Semaphore Testing 1  - Different semaphore Key >

[Thread id : 2, Semaphore key :   10002] Enter critical section.
[Thread id : 2, Semaphore key :   10002] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] Enter critical section.
[Thread id : 1, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :   10000] Enter critical section.
[Thread id : 3, Semaphore key :   10000] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :   10002] After sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 3, Semaphore key :   10000] After sleep (0.01msec).
[Thread id : 2, Semaphore key :   10002] Out critical section.

[Thread id : 1, Semaphore key :   10001] Out critical section.

[Thread id : 3, Semaphore key :   10000] Out critical section.

< Simple Semaphore Testing 2  - Same semaphore Key >

[Thread id : 1, Semaphore key :   10001] Enter critical section.
[Thread id : 1, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] Out critical section.

[Thread id : 2, Semaphore key :   10001] Enter critical section.
[Thread id : 2, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 2, Semaphore key :   10001] Out critical section.

[Thread id : 3, Semaphore key :   10001] Enter critical section.
[Thread id : 3, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 3, Semaphore key :   10001] Out critical section.

##############################################################################
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< Dining Philosopher - There are five Philosopher(s), Deadlock Prevention : [o] >

[Thread ID : 4] 'θαλής' ate spaghetti [1] times !!

[Thread ID : 1] 'René Descartes' ate spaghetti [1] times !!

[Thread ID : 5] 'Πλάτων' ate spaghetti [1] times !!

[Thread ID : 3] 'Σωκράτης' ate spaghetti [1] times !!

[Thread ID : 5] 'Πλάτων' ate spaghetti [2] times !!

[Thread ID : 3] 'Σωκράτης' ate spaghetti [2] times !!

[Thread ID : 4] 'θαλής' ate spaghetti [2] times !!

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [1] times !!

[Thread ID : 3] 'Σωκράτης' ate spaghetti [3] times !!

[Thread ID : 1] 'René Descartes' ate spaghetti [2] times !!

[Thread ID : 5] 'Πλάτων' ate spaghetti [3] times !!

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [2] times !!

[Thread ID : 1] 'René Descartes' ate spaghetti [3] times !!

[Thread ID : 4] 'θαλής' ate spaghetti [3] times !!

[Thread ID : 5] 'Πλάτων' ate spaghetti [4] times !!

[Thread ID : 3] 'Σωκράτης' ate spaghetti [4] times !!

[Thread ID : 4] 'θαλής' ate spaghetti [4] times !!

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [3] times !!

[Thread ID : 3] 'Σωκράτης' ate spaghetti [5] times !!

[Thread ID : 1] 'René Descartes' ate spaghetti [4] times !!

[Thread ID : 2] 'François Marie Arouet' ate spaghetti [4] times !!

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[Thread ID : 5] 'Πλάτων' ate spaghetti [5] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [5] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [5] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [6] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [6] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [6] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [5] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [6] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [7] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [6] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [7] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [7] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [7] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [8] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [8] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [8] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [7] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [8] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [9] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [8] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [9] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [9] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [10] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [9] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [9] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [10] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [11] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [10] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [10] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [11] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [10] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [12] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [11] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [11] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [12] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [11] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [13] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [12] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [12] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [13] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [14] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [12] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [14] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [13] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [13] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [15] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [13] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [15] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [14] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [14] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [16] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [14] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [15] times !!
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[Thread ID : 5] 'Πλάτων' ate spaghetti [16] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [15] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [15] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [17] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [16] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [17] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [16] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [16] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [18] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [17] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [18] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [17] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [17] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [19] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [18] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [19] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [18] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [18] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [20] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [19] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [20] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [19] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [19] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [21] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [20] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [21] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [20] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [20] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [22] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [21] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [22] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [21] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [21] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [23] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [22] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [23] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [22] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [22] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [24] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [23] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [24] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [23] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [23] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [25] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [24] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [25] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [24] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [24] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [26] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [25] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [26] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [25] times !!
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[Thread ID : 3] 'Σωκράτης' ate spaghetti [25] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [27] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [26] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [27] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [26] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [26] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [28] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [27] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [28] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [27] ti
[Thread ID : 3] 'Σωκράτης' ate spaghetti [27]
[Thread ID : 2] 'François Marie Arouet' ate s
[Thread ID : 1] 'René Descartes' ate spaghett
[Thread ID : 5] 'Πλάτων' ate spaghetti [29] t
[Thread ID : 4] 'Θαλής' ate spaghetti [28] ti
[Thread ID : 3] 'Σωκράτης' ate spaghetti [28]
[Thread ID : 2] 'François Marie Arouet' ate s
[Thread ID : 1] 'René Descartes' ate spaghett
[Thread ID : 5] 'Πλάτων' ate spaghetti [30] t
[Thread ID : 4] 'Θαλής' ate spaghetti [29] t
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3초간 철학자 스래드들의 반응이 없을 때, 관찰자 스래드는 이를 감지합니다.

그 후, 현재 교착상태임을 알리고, 테이블 위에 모든 포크가 놓일 때 까지 철학자 스래드를 대기시킵니다.

위 과정이 완벽하게 진행 된 후엔, 철학자들은 다시 식사를 하게 됩니다.

```
 ** now deadlock **

#### FORK is now [ (fork1) : 1, (fork2) : 1, (fork3) : 1, (fork4) : 1, (fork5) : 1 ] On a
Table !! ####

[Thread ID : 1] 'René Descartes' ate spaghetti [30] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [29] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [31] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [31] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [31] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [30] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [30] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [32] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [32] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [31] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [32] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [33] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [31] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [34] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [32] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [33] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [33] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [34] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [33] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [35] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [36] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [32] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [35] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [34] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [34] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [36] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [35] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [37] times !!
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[Thread ID : 4] 'Θαλής' ate spaghetti [33] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [36] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [43] times !!
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[Thread ID : 1] 'René Descartes' ate spaghetti [43] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [38] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [45] times !!
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[Thread ID : 1] 'René Descartes' ate spaghetti [48] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [50] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [39] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [48] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [49] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [41] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [51] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [50] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [49] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [40] times !!
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[Thread ID : 1] 'René Descartes' ate spaghetti [55] times !!
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[Thread ID : 3] 'Σωκράτης' ate spaghetti [54] times !!
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[Thread ID : 1] 'René Descartes' ate spaghetti [57] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [58] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [59] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [57] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [44] times !!
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[Thread ID : 3] 'Σωκράτης' ate spaghetti [58] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [60] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [46] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [60] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [59] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [61] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [45] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [61] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [60] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [62] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [61] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [62] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [63] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [47] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [62] times !!
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[Thread ID : 4] 'Θαλής' ate spaghetti [46] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [63] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [64] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [63] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [48] times !!
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[Thread ID : 3] 'Σωκράτης' ate spaghetti [65] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [67] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [66] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [48] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [66] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [68] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [67] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [50] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [67] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [69] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [68] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [49] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [70] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [68] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [69] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [71] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [51] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [69] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [70] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [50] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [72] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [70] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [71] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [52] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [71] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [73] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [72] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [51] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [72] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [74] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [73] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [53] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [75] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [74] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [73] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [54] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [75] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [76] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [74] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [76] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [52] times !!
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[Thread ID : 2] 'François Marie Arouet' ate spaghetti [77] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [75] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [77] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [55] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [78] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [76] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [53] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [78] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [79] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [77] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [56] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [79] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [80] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [78] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [80] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [54] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [81] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [79] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [81] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [57] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [82] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [80] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [55] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [82] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [83] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [81] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [58] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [83] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [84] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [82] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [56] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [84] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [85] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [83] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [59] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [86] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [85] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [84] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [57] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [86] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [87] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [85] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [60] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [87] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [88] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [86] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [58] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [88] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [89] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [87] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [61] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [89] times !!
```

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[Thread ID : 3] 'Σωκράτης' ate spaghetti [88] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [90] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [59] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [90] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [89] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [91] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [62] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [91] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [92] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [90] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [92] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [60] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [91] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [93] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [93] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [63] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [94] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [92] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [94] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [61] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [95] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [93] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [95] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [64] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [96] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [94] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [96] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [62] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [97] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [95] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [97] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [65] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [96] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [98] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [63] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [98] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [97] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [99] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [99] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [66] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [98] times !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti [100] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [64] times !!
[Thread ID : 1] 'René Descartes' ate spaghetti [100] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [99] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [67] times !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti [100] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [65] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [68] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [66] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [69] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [67] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [70] times !!
```

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[Thread ID : 4] 'Θαλής' ate spaghetti [68] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [71] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [69] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [72] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [70] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [73] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [71] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [74] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [72] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [75] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [73] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [76] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [74] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [77] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [75] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [78] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [76] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [79] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [77] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [80] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [78] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [81] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [79] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [82] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [80] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [83] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [81] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [84] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [82] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [85] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [83] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [86] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [84] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [87] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [85] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [88] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [86] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [89] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [90] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [87] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [91] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [88] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [92] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [89] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [93] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [90] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [94] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [91] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [95] times !!
[Thread ID : 4] 'Θαλής' ate spaghetti [92] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [96] times !!
```

각 철학자들이 100 만큼을 먹어야 배가 찬다고 할 때, **데카르트(1)**과 **볼테르(2)**, 그리고 소크라테스(3)가 식사를 마치는 동안, **탈레스(4)**와 **플라톤(5)**는 **겨우 2/3 가량 먹었습니다**.

즉, **자원 분배가 고르게 되지 않았음**을 알 수 있습니다.

```
[Thread ID : 4] 'θαλής' ate spaghetti [93] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [97] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [94] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [98] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [95] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [99] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [96] times !!
[Thread ID : 5] 'Πλάτων' ate spaghetti [100] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [97] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [98] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [99] times !!
[Thread ID : 4] 'θαλής' ate spaghetti [100] times !!
Program ended with exit code: 0
```

 이로써 교착상태는 완전히 해결하였습니다. 하지만 위의 결과에서 보이듯 여전히 **철학자들이 공평하게 식사를 하지 못하는 것**을 알 수 있습니다. 따라서 다시 원점으로 돌아와, 다른 방법을 이용하여 철학자들이 공평하게 식사를 할 수 있게 하고자 합니다.
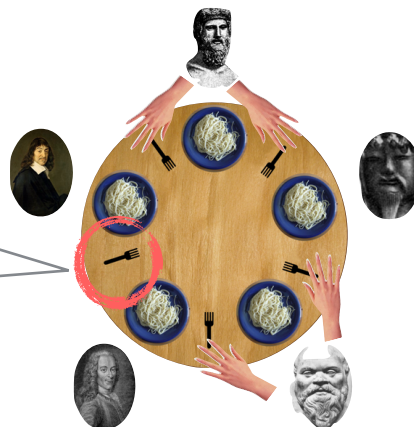
 테이블에는 다섯 개의 포크가 놓여져 있습니다. 즉 최대 두 명의 철학자가 동시에 스파게티를 먹을 수 있습니다. 이를 구현하기 위해선 두 철학자가 동시에 포크를 잡는 행위를 해야 하는데 위의 프로그램에선 이런 행위를 구현함에 어려움과 제한사항이 따릅니다. 따라서 철학자들이 식사과정을 다른 방법으로 바꾸어야 했습니다.

 아까 언급했듯, 최대 두 명의 철학자가 동시에 스파게티를 먹습니다. 이는 즉, 이 상황에서 적어도 하나의 포크는 식사에 이용되고 있지 않습니다. 이 점에 착안하여 다음과 같은 식사과정으로 새로 구현해 보았습니다.

- 처음에는 **1번 포크**를 쉬게 하자. 이때 **볼테르**와 **탈레스**가 동시에 스파게티를 먹을 수 있다.
- 시간이 지나면 이제 **2번 포크**를 쉬게 하자. 이때 **소크라테스**와 **플라톤**이 동시에 스파게티를 먹을 수 있다.
- 시간이 지나면 이제 **3번 포크**를 쉬게 하자. 이때 **데카르트**와 **탈레스**가 동시에 스파게티를 먹을 수 있다.
- 시간이 지나면 이제 **4번 포크**를 쉬게 하자. 이때 **볼테르**와 **플라톤**이 동시에 스파게티를 먹을 수 있다.
- 시간이 지나면 이제 **5번 포크**를 쉬게 하자. 이때 **데카르트**와 **소크라테스**가 동시에 스파게티를 먹을 수 있다

 다섯개의 포크로 최대 2명의 철학자가 식사를 할 수 있습니다.

 즉, 어떤 신호에 따른 **먹는 순서를 정해준다면**, 다같이 공평하게 문제없이 행복한 식사를 할 수 있을 것 입니다.

[포크 하나가 철학자의 입 밖에 있다. == 네 개의 포크가 철학자의 입 속에 들어가 있을 수 있다.]

포크는 모두 테이블에 놓여 있습니다. 지목된 포크를 기준으로 일정시간 동안 특정 철학자 둘에게 무한한 권한을 줍니다. 철학자 둘은 일정기간동안 젓가락을 마음껏 사용할 수 있습니다. 포크 분배가 불공평하게 되거나, 교착상 태에 빠져드는 일은 없습니다.

다음은 터미널 출력 시작과 끝의 일부입니다.

```
##########################################################################

< Simple Semaphore Testing 1  - Different semaphore Key >

[Thread id : 2, Semaphore key :   10002] Enter critical section.
[Thread id : 1, Semaphore key :   10001] Enter critical section.
[Thread id : 3, Semaphore key :   10000] Enter critical section.
[Thread id : 2, Semaphore key :   10002] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :   10000] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :   10002] After sleep (0.01msec).
[Thread id : 3, Semaphore key :   10000] After sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 2, Semaphore key :   10002] Out critical section.

[Thread id : 3, Semaphore key :   10000] Out critical section.

[Thread id : 1, Semaphore key :   10001] Out critical section.

< Simple Semaphore Testing 2  - Same semaphore Key >

[Thread id : 2, Semaphore key :   10001] Enter critical section.
[Thread id : 2, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 2, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 2, Semaphore key :   10001] Out critical section.

[Thread id : 1, Semaphore key :   10001] Enter critical section.
[Thread id : 1, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 1, Semaphore key :   10001] Out critical section.

[Thread id : 3, Semaphore key :   10001] Enter critical section.
[Thread id : 3, Semaphore key :   10001] Before sleep (0.01msec).
[Thread id : 3, Semaphore key :   10001] After sleep (0.01msec).
[Thread id : 3, Semaphore key :   10001] Out critical section.

##########################################################################


< Dining Philosopher  - There are five Philosopher(s), Deadlock Prevention : [s] >


 < eatingTimes 499 left >.
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
[Thread ID : 4] 'θαλής' ate spaghetti !!
--> Descartes : 0 , Voltaire : 1, Sokrates : 0, Thales : 1, Plato : 0  times eat
Spaghetti.

 < eatingTimes 498 left >.
[Thread ID : 1] 'René Descartes' ate spaghetti !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
--> Descartes : 1 , Voltaire : 1, Sokrates : 1, Thales : 1, Plato : 0  times eat
Spaghetti.

 < eatingTimes 497 left >.
```

```
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
--> Descartes : 1 , Voltaire : 2, Sokrates : 1, Thales : 1, Plato : 1  times eat
Spaghetti.

 < eatingTimes 496 left >.
[Thread ID : 4] 'θαλής' ate spaghetti !!
[Thread ID : 1] 'René Descartes' ate spaghetti !!
--> Descartes : 2 , Voltaire : 2, Sokrates : 1, Thales : 2, Plato : 1  times eat
Spaghetti.

 < eatingTimes 495 left >.
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
--> Descartes : 2 , Voltaire : 2, Sokrates : 2, Thales : 2, Plato : 2  times eat
Spaghetti.

 < eatingTimes 494 left >.
[Thread ID : 4] 'θαλής' ate spaghetti !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
--> Descartes : 2 , Voltaire : 3, Sokrates : 2, Thales : 3, Plato : 2  times eat
Spaghetti.

 < eatingTimes 493 left >.
[Thread ID : 1] 'René Descartes' ate spaghetti !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
--> Descartes : 3 , Voltaire : 3, Sokrates : 3, Thales : 3, Plato : 2  times eat
Spaghetti.

 < eatingTimes 492 left >.
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
--> Descartes : 3 , Voltaire : 4, Sokrates : 3, Thales : 3, Plato : 3  times eat
Spaghetti.

 < eatingTimes 491 left >.
[Thread ID : 4] 'θαλής' ate spaghetti !!
[Thread ID : 1] 'René Descartes' ate spaghetti !!
--> Descartes : 4 , Voltaire : 4, Sokrates : 3, Thales : 4, Plato : 3  times eat
Spaghetti.

 < eatingTimes 490 left >.
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
--> Descartes : 4 , Voltaire : 4, Sokrates : 4, Thales : 4, Plato : 4  times eat
Spaghetti.

 < eatingTimes 489 left >.
[Thread ID : 4] 'θαλής' ate spaghetti !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
--> Descartes : 4 , Voltaire : 5, Sokrates : 4, Thales : 5, Plato : 4  times eat
Spaghetti.

 < eatingTimes 488 left >.
[Thread ID : 1] 'René Descartes' ate spaghetti !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
--> Descartes : 5 , Voltaire : 5, Sokrates : 5, Thales : 5, Plato : 4  times eat
Spaghetti.
```

[· · · · · ·]

```
 < eatingTimes 9 left >.
[Thread ID : 4] 'Θαλής' ate spaghetti !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
--> Descartes : 196 , Voltaire : 197, Sokrates : 196, Thales : 197, Plato : 196  times
eat Spaghetti.

 < eatingTimes 8 left >.
[Thread ID : 1] 'René Descartes' ate spaghetti !!
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
--> Descartes : 197 , Voltaire : 197, Sokrates : 197, Thales : 197, Plato : 196  times
eat Spaghetti.

 < eatingTimes 7 left >.
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
--> Descartes : 197 , Voltaire : 198, Sokrates : 197, Thales : 197, Plato : 197  times
eat Spaghetti.

 < eatingTimes 6 left >.
[Thread ID : 4] 'Θαλής' ate spaghetti !!
[Thread ID : 1] 'René Descartes' ate spaghetti !!
--> Descartes : 198 , Voltaire : 198, Sokrates : 197, Thales : 198, Plato : 197  times
eat Spaghetti.

 < eatingTimes 5 left >.
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
--> Descartes : 198 , Voltaire : 198, Sokrates : 198, Thales : 198, Plato : 198  times
eat Spaghetti.

 < eatingTimes 4 left >.
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
[Thread ID : 4] 'Θαλής' ate spaghetti !!
--> Descartes : 198 , Voltaire : 199, Sokrates : 198, Thales : 199, Plato : 198  times
eat Spaghetti.

 < eatingTimes 3 left >.
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
[Thread ID : 1] 'René Descartes' ate spaghetti !!
--> Descartes : 199 , Voltaire : 199, Sokrates : 199, Thales : 199, Plato : 198  times
eat Spaghetti.

 < eatingTimes 2 left >.
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
[Thread ID : 2] 'François Marie Arouet' ate spaghetti !!
--> Descartes : 199 , Voltaire : 200, Sokrates : 199, Thales : 199, Plato : 199  times
eat Spaghetti.

 < eatingTimes 1 left >.
[Thread ID : 4] 'Θαλής' ate spaghetti !!
[Thread ID : 1] 'René Descartes' ate spaghetti !!
--> Descartes : 200 , Voltaire : 200, Sokrates : 199, Thales : 200, Plato : 199  times
eat Spaghetti.

 < eatingTimes 0 left >.
[Thread ID : 3] 'Σωκράτης' ate spaghetti !!
[Thread ID : 5] 'Πλάτων' ate spaghetti !!
```
**--> Descartes : 200 , Voltaire : 200, Sokrates : 200, Thales : 200, Plato : 200 times
eat Spaghetti.**
```
Program ended with exit code: 0
```

이로써 모든 문제를 해결하였습니다. (소스코드는 가상강의실에 별첨하였습니다.)